STUDIES ON YIELDING CAPACITY OF RICE VARIETIES CULTIVATED IN TAIWAN UNDER HIGH AND LOW TEMPERATURE*

by

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In order to measure influences of different temperature conditions on the yielding capacity of rice varieties in Taiwan, three localities at different sea levels, i. e. Taipei (15 m. above the sea level) Wu-lai (220 m., 1–2°C lower than in Taipei) and Chu-tsu-fu (660 m., 3–5°C lower than in Taipei) were selected as the site of the experiment. In the 1st crop period of 1959, 4 rice varieties (Japonica) were planted in pots with ten replications filled with the same soil and with the same amount of fertilizers to evaluate the effect of temperatures on fertilizer response and yielding capacity. The results of this experiment indicated that at Wu-lai where the temperature was lower gave a highest yield on the average, while at Taipei with a higher temperature the yield was lowest. Whereas at Chu-tzu-fu where the temperature was lowest than the two localities being mentioned showed intermediate.

Table I. Comparison of Grain Yields, 1st crop, 1959

(1) Among Varieties:

Variety	Yield	Difference		
Chia-nung 242	1009.7			
Taichung 65 (36 day seedling)	772.5	337.2**		
Chia-nun 8	676.9	332.8**	95.6	
Taichung 65 (57 day seedling)	577.0	432.7**	195.5**	99.5

Standard of significant difference
5%.....100.65
1%.....132.28

when we compared the total yields of the three places, it was found that Chia-nung 242 was the highest yielder, Taichung 65 (with 36 day seedling), the medium one, and Taichung 65 (with 57 day seedling), the lowest.

(2) Among Sea Levels:

Sea level	Yield	Difference	
220 m.	1092.4		
660 m.	1016.4	76.0	
15 m.	927.3	165.1**	89.1

Standard of significant difference
5%.....116.21
1%.....152.73

Among the different sea levels, rice yielded highest at 220 m. there showed a very significant difference when compared with the grain yield at 15 m.

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From the analysis of variance, the interaction between the variety and the altitude was also very significant. Chia-nung 242 grown at Wu-lai (220 m.) is the highest in grain yield, and Taichung 65 at Taipei (15 m.), the next.

Table II. Comparison of Grain Yields, 2nd Corp, 1959

(1) Among Varieties:

Variety	Yield	Difference			
Hsinchu 56	890.3				
Chia-nung 242	890.0	0.3			
Taichung 65	826.0	64.3**	94.0**		
Chia-nan 8	796.0	94.3**	94.0**		
Baritol	779.9	110.4**	110.1**	46.1*	16.1

Standard of significant difference

5%.....44.28

1%.....58.19

In the 2nd crop, 1959, the difference in yield among the varieties is even more significant, in which, Hsinchu 56 & Chia-nung 242 are the highest yielders, and Taichung 65, the next.

(2) Among Sea Levels:

Sea Level	Yield	Difference
220 m.	2150.4	
15 m.	2032.0	118.4**
660 m.	0	——— ———

At 660m. altitude no yield was obtained due to the low temperature.

Standard of significant difference

5%.....69.99

1%.....91.99

The grain yield of rice grown at 220 m. above sea level is higher than at Taipei plain (15 m.), and their difference is very significant.

The interaction between variety and altitude is also significant, in which Hsinchu 56 and Chia-nung 242 grown at Wu-lai (220 m.) were among the highest yielders, and Chia-nung 242 at Taipei plain (15 m.) yielded little less than the formers.

From the above record, as given by the first & second crops of 1959, the yield of varieties at 220 m. above sea level with a relatively low temperature showed the highest. The causes of increased yield were attributed to the high 1,000 grain weight. In so far as the varieties used (Japonica type) are concerned, it seems to be that a higher yield may result when the plants were grown at a relatively low temperature. It was further suggested that the relatively low temperatures at Wu-lai may induce a high fertilizer response.

In 1960 and 1961, the similar test was continued. In addition to the three levels of fertilizer treatment being used, namely: (a) Half rate, only compost applied at a rate of 6,000 kg/ha. with no chemical fertilizers added; (b) Standard rate, besides

the compost applied, chemical fertilizers were added at a rate of N:P:K=80:40:40 kg/ha.; (c) double rate, with the same amount of compost plus double dose of chemical fertilizers added at a rate of N:P:K=160:80:80 kg/ha. As for varieties used, four Japonicas and two Indicas were included with 4 replications so as to make the experiment a more comprehensive one. The results are shown in the following tables:

Table 1. The Difference in Yielding Capacity of the First Crop of Indica and Japonica Type of Rice Grown under Different Sea Levels, 1960 & 1961 (Totals of three fertilizer treatments)

Altitude	Yield in Grams of Japonica Rice (Average of 4 Varieties)			Yield in Grams of Indica Rice (Average of 2 Varieties)			Difference (Indica − Japonica)	Total (Indica + Japonica)
	1960	1961	Total	1960	1961	Total		
15 m.	339.9	415.1	755.0	460.9	657.1	1,118.0	+363.0**	1,873.0
220 m.	330.4	533.4	883.8	522.7	488.1	1,010.8	+127.0*	1,894.6
660 m.	213.9	492.3	702.2	348.2	239.2	587.4	−118.8**	1,293.6

Table 2. The Difference in Yielding Capacity of the 2nd Crop

Altitude	Yield in Grams of Japonica Rice (Average of 4 Varieties)			Yield in Grams of Indica Rice (Average of 2 Varieties)			Difference (indica − Japonica)	Total (Indica + Japonica)
	1960	1961	Total	1960	1961	Total		
15 m.	438.7	321.8	760.5	448.0	278.8	726.8	− 33.7	1,487.3
220 m.	468.7	386.4	855.1	427.3	270.3	697.0	−157.5**	1,552.7
660 m.	283.0	0.0 (Cold weather damage)	—	355.3	0.0 (Cold weather damage)	—	—	668.3 (No harvest during 2nd Crop 1961)

* Significant
** Very significant

From the above two tables, one can see that the results is coincide to the year 1959, i. e. the Japonica rice yielded higher at the 220 m. above sea level, both in the 1st & the 2nd crops as a result of their high 1,000-grain weight, in addition to that there was less insect and disease damages in the environs at the 220 m. altitude.

In the first crop at the 15 m. & 220 m. sea levels, the Indica rice yielded higher than the Japonica, but in the 2nd crop, the Japonica rice always gave a better yield than the Indica rice at all the three levels. According to $\frac{D}{P.E.}$ formula to find odds by which one can judge whether the difference is significant or not.

From tables 3 & 4, we may find that the pots with standard treatment gave the highest yield, while those with the half or double doses of the fertilizer both decreased the grain yield. Thus at the 220 m. above sea level a high fertilizer response may be induced. In the first crop, the yielding capacity of Indica rice was somewhat higher than the Japonica type at the altitudes of 15 m. and 220 m.. In looking forward to the development of the 1st crop of Indica rice in this Island it should be rather promising as viewed from the above data obtained.

Table 3. The Total Yield in Grams with Index of the 1st Crop, 1960 & 1961, Treated with Different Fertilizers

Rice type / Fertilizer / Altitude	Japonica			Indica		
	(A) Half dose	(B) Standard dose	(C) Double dose	(A) Half dose	(B) Standard dose	(C) Double dose
15 m.	205.1 (80.6)	310.3 (100)	194.6 (62.7)	341.0 (85.3)	399.8 (100)	377.2 (94.3)
220 m.	287.3 (87.4)	328.8 (100)	267.7 (81.4)	335.3 (80.1)	418.5 (100)	267.0 (63.8)
660 m.	228.5 (92.1)	248.1 (100)	229.6 (92.5)	202.8 (92.8)	218.6 (100)	166.0 (75.9)

Table 4. Yield in Grams with Standard Fertilizer Treatment, 1st Crop of 1960 & 1961

Altitude		Yield with Standard Treatment	Index
15 m.	Jap.	310.3	100.00
	Ind.	399.8	100.00
220 m.	Jap.	328.8	105.96*
	Ind.	418.5	104.67*
660 m.	Jap.	248.1	79.95
	Ind.	218.6	54.67

* Difference Significant

Table 5. The total Yield in Grams with Index of the 2nd crop, 1960 & 1961, Treated with Different Fertilizers

Rice type / Fertilizer / Altitude	Japonica			Indica		
	(A) Half dose	(B) Standard dose	(C) Double dose	(A) Half dose	(B) Standard dose	(C) Double dose
15 m.	190.2 (67.8)	280.6 (100)	289.7 (103.2)	166.9 (59.1)	282.3 (100)	277.6 (98.3)
220 m.	195.4 (59.5)	328.2 (100)	331.5 (101.0)	143.3 (52.8)	271.2 (100)	283.1 (104.4)
660 m.	NO harvest during 2nd crop, 1961 by means of cold damage					

Table 6. Yield in Grams of the 2nd Crop with Standard Fertilizer Treatment, 1960 & 1961

Altitude		Yield of Standard Treatment	Index
15 m.	Jap.	280.6	100.00
	Ind.	282.3	100.00
220 m.	Jap.	328.2	117.00**
	Ind.	271.2	96.10

From the tables 5 and 6, we may find that the 2nd crops, if chemical fertilizer were lacking, they may greatly reduce the grain yield. It should be noted, however, that with the analysis of variance, it indicated that the increase in yield due to doubling of fertilizer dosage has not always been significant, which demonstrates that the standard dose of fertilizer may give a more reasonable return.

According to the results of this 3-year experiment, we find that the Ponlai rice (Japonica) had always a better harvest of grain at the locality with the 220 m. altitued where the temperature was lower, and apparently the yielding capacity of which was repressed by the tropical high temperature which prevailed at the 15 m. plain in hot seasons. On the contrary, most of the native varieties (Indica) were easily lodged and their grain yield was thus always badly effected by this character. It is reasonable to deduce from the facts that if we use Indica varieties of South-east Asia origin or formerly introduced from China mainland as parent to cross with modern Ponlai rice, there should be great possibilities of developing new Ponlai rice with greater adaptabilities to the tropical climate. In the breeding of native rice varieties emphasis should be made to the selection of non-lodging strains besides they should able to tolerate heavy fertilizers.

Mention should be made that we had used bamboo sticks to support the plants of native rice in this experiment, so the yielding capacity of native varieties in the first crops was much better than the Ponlai rice when grown at the 15 m. and 220 m. altitude. It was in this way that the Indica varieties were prevented from lodging and hence gave yields more than expected in the 1st crops.

REFERENCES

(1) 臺灣省氣象所：每日氣溫紀錄 (1959, 1960 及 1961).
(2) Eikichi Iso: Some Considerations on the Regional Adaptability of Rice Varieties with Special Reference to the Recent Development on the Yield per Unit Area in Taiwan (1947).
(3) 張守敬、曾憲鼎、步焕昇：臺灣省水稻三要素適量試驗結果之檢討 (1948).
(4) 林寶鑫：臺中在來一號 (1961).
(5) N. Parthasarathy: Progress Report on Breeding Program in India (1956).

高溫及低溫下臺灣稻品種生產力之比較研究

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摘　　要

本研究利用臺北市近郊，三種不同海拔高度，作爲高溫及低溫之試驗環境。卽①臺北農試所，海拔 15 m.。②烏來，海拔 220 m.。③竹子湖，海拔 660 m.。以農試所爲標準，烏來氣溫平均比本所低 1-2°C，竹子湖平均比本所低 3-5°C。第一年（民國48年，1959）用蓬萊種四品種，爲試驗材料，結果以海拔220公尺稍低溫環境下，稻谷生產量最高，其增產之積極原因，係由於 220 m. 較低溫環境下，谷粒千粒重加重。第二年（民國49年，1960）及第三年（民國50年，1961）以蓬萊種四，在來種二爲試驗材料，結果在第一期作，海拔 15 m. 及 220 m. 情形下，在來種產量優於蓬萊種。而在第二期作，在平地（15 m.）蓬萊種在來種無大差別，但在 220 m. 山地，蓬萊種優於在來種，亦優於 15 m. 下同品種收量，差異十分顯著。220 m. 之環境，所以促進蓬萊種增產，仍歸功於稍低溫環境下谷粒千粒重加重。此外病蟲害亦較平地爲少。惟本試驗曾用支柱使在來種免於倒狀。三種肥料處理，（半肥、標準肥、倍肥）仍以標準肥區（N:P:K=80:40:40）最爲經濟實惠，故今後在來種如育成短莖强稈耐肥不倒伏品種，蓬萊種加深秈稻血緣，均可能進一步增產。